Space Weather Technical Forecast

Issued on Saturday, 27 August 2022 at 12:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-class flares Likely. Chance of X-class flares. G1 Minor Storm possible with CME glance late day 2 or early day 3 (28th or 29th). S1 Storm in progress.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Moderate, with the background X-ray trace at GOES16 well into C-class levels. There were numerous M-class flares including several in a short period of time starting with an M7 flare (the largest of the period) at 26/1215 UTC. These primarily came from AR3089 (Eai/Beta) in the southeast, which has subsequently eased, but overlaid a longer period M-flare perhaps from AR3088 (Ekc/Beta-Gamma) in the southwest. A further long period M4.9 flare was then observed from AR3088 in the southwest, peaking 29/0240 UTC. This region is approaching the southwest limb, making viewing difficult, but is a large and relatively complex region, with a north-south aligned field and ongoing frequent C-flaring. The first series of M-flares were accompanied with a sequence of CMEs off the southwest disc, however these have been assessed as either far-sided or missing. The second CME also produced a fast CME, which has been assessed as giving a glancing impact late on the 28th or early 29th, although confidence is low due to limited SOHO imagery and the flare location.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, was indicative of an ongoing coronal hole fast wind arrival. The wind speed was mainly at background 330-370km/s, however the density increased from below average levels, to above average, peaking around 30-35 ppcc. The total interplanetary magnetic field (IMF), Bt, was weak at below 7nT until around 27/0800 UTC, when it became moderate 8-14nT. The north-south component was initially unremarkable, but became predominately negative (southward) from 27/0900 UTC, reaching -10nT. The phi angle was negative (towards the Sun) throughout. Geomagnetic activity was Quiet, but increased to Unsettled by 27/0900-1200 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV), as measured by GOES-16, rose from background levels from 27/0635 UTC to peak at S1, reaching 13.5 pfu at 27/1200 UTC, likely in response to the M4.9 flare of AR3088. The high energy electron flux (greater than 2 MeV) was initially at High levels, with a peak of 3600pfu at 26/1810UTC but fell to Background to Moderate levels from 27/0000 UTC. The 24-hour integrated electron fluence remained above the Active threshold (1e8 integrated pfu) on a steady trend, with 1.83e8 integrated pfu observed at 27/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Further M-class flares are likely with a slight chance of an X-class flare. A gradual decrease is likely later in the period as AR3088 rotates off the southwest limb.

Solar Wind / Geomagnetic Activity: There is one CME which has the potential to give a glancing arrival late on the 28th or early 29th. Current coronal hole fast wind enhancement from CH18 is expected to give Active with a chance of G1 Minor Storm geomagnetic activity on day 1. Further enhancement day 2 or day 3 is likely from CH17, coupled with any CME arrival, and has the potential to give Active to G1/Minor Storms, with a slight chance of G2/Moderate storms.

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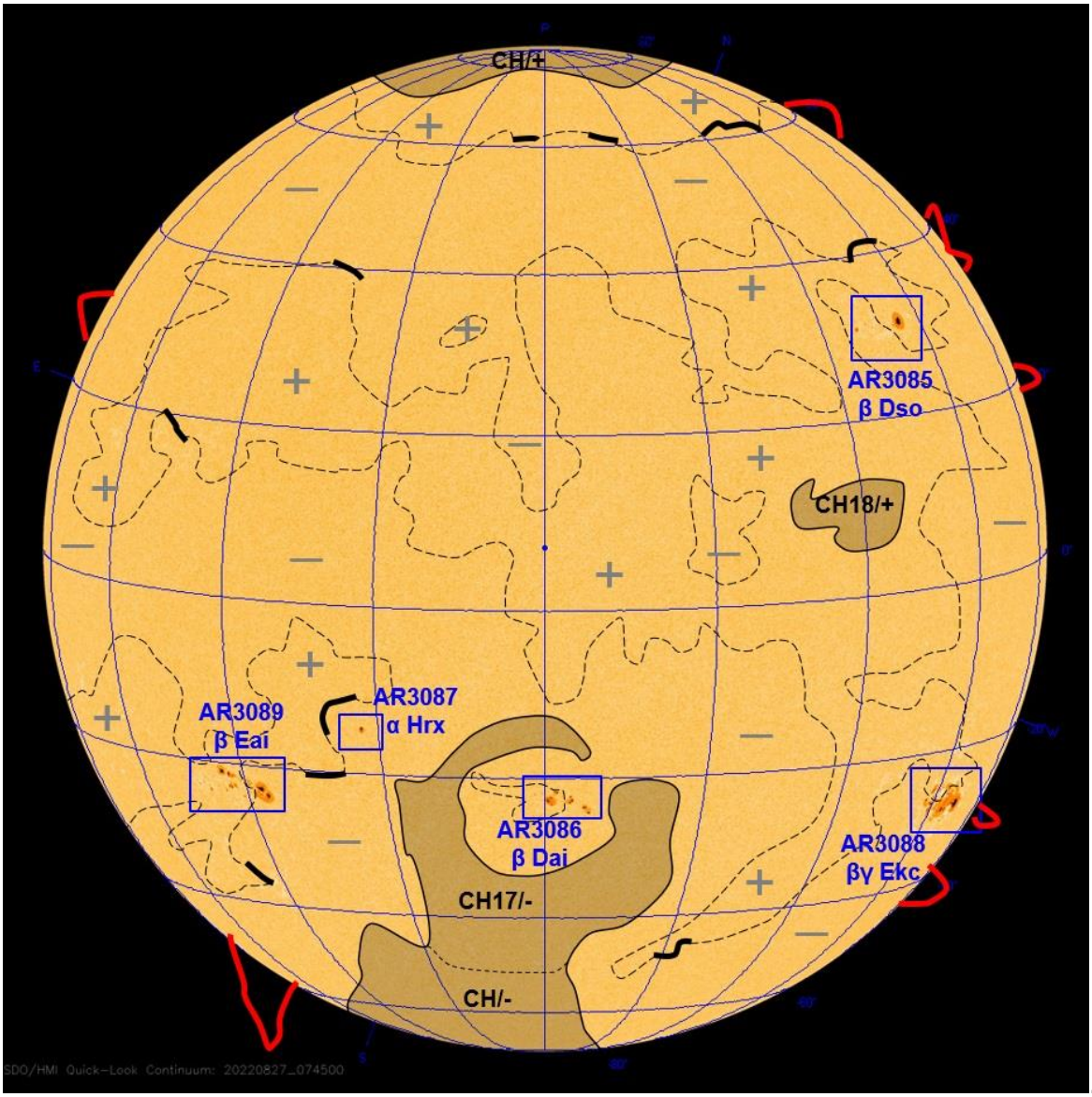
Thereafter conditions are expected to ease towards background with increasingly Quiet geomagnetic activity.

Energetic Particles / Solar Radiation: High energy protons (greater than 10MeV) are currently above the S1-storm level, but are expected to ease later day 1 (27th). Any further notable flaring from AR3088 has the potential to cause proton flux values to increase above this level. The high energy (greater than 2 MeV) electron flux forecast is low confidence, with any recovery of values day 1 and 2 (27th and 28th) likely to see further decreases as any fast wind or CME arrival occurs. A recovery in values is likely thereafter, however this is low confidence at this stage. Current Active fluence is likely to fall below this level later on day 1 (27th). With low confidence in the flux forecast, further Active fluence is currently uncertain, but most likely to occur later in the period.

Figure 1. Solar Analysis Valid 27/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The M4.9 flare of AR3088 on the 27th, produced a moderately fast CME. This has been analysed as potentially having an Earth-directed component, giving a chance of a glancing impact, either late day 2 (28th) or on early day 3 (29th). There is some uncertainty however, due to the southern and westward location of the source eruption, giving the chance for the CME to miss, passing ahead of the Earth. Any Earth-sided CME associated with the M-flaring observed on the 26th is now expected to miss or be subsumed into this CME.

Earth is currently connecting to the fast wind of positive polarity coronal hole 18. This is an immature feature, newly developed on this rotation, but has resulted in some moderately southward pointed IMF, likely due to the Russell-McPherron effect, where positive coronal holes are more geoeffective closer to the Autumn equinox. Due to this moderate southward IMF, Unsettled to Active intervals are expected with G1/minor storms possible at first day 1 (27th) before geomagnetic conditions ease into day 2 (28th).

A further fast wind arrival due negative polarity CH17 is then expected day 2, or possibly early day 3 (28th or 29th). This is a large feature in the southern hemisphere, and recurrent, although being an extension of the southern polar crown, is delayed compared to the usual 27 day persistence which suggests an arrival on day 1 (27th). Enlil also has an arrival on day 1, but currently doesn't account for the ongoing fast wind arrival of CH18.

With the potential for fast wind onset, alongside a glancing CME arrival, there is a chance for Active to G1/Minor storm conditions perhaps late day 2 (28th) or more likely day 3 (29th), with G2/Moderate storm intervals possible. These conditions easing later day 3. Otherwise geomagnetic activity is expected to be mainly Quiet with isolated Unsettled spells, once any initial activity day 1 (27th) subsides.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	40	60	1
Strong	G3	No	1	5	5	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
27/0515	Partial	AR3088	SW	1250 km/s	29/0100 +/- 9 hours	Low confidence. Glancing blow

Figure 2a: Current Observed Solar winds

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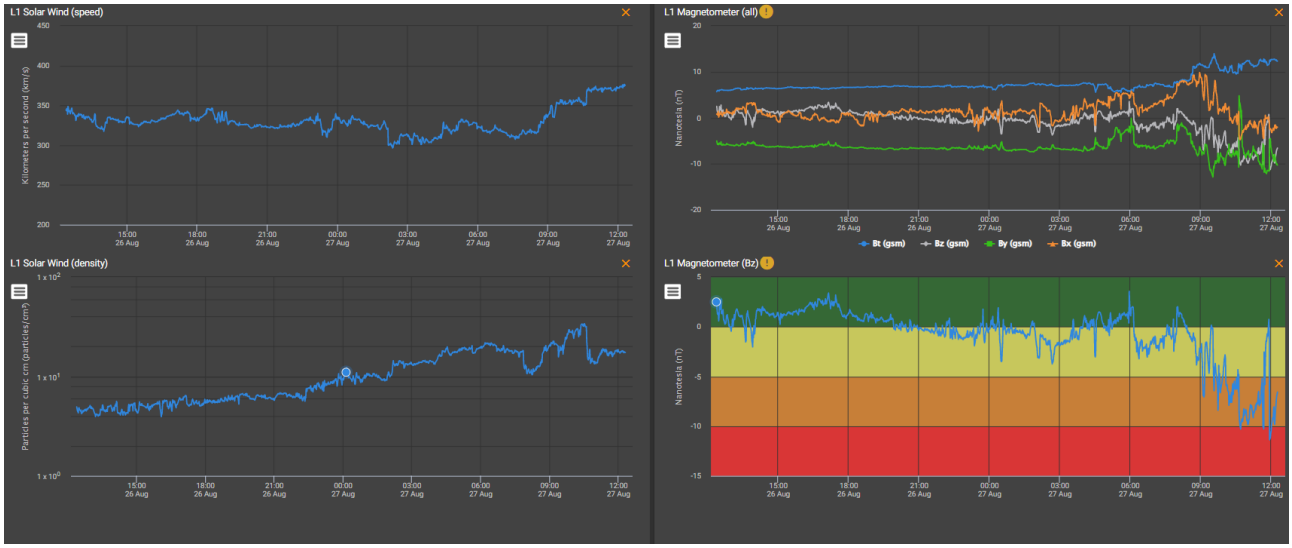
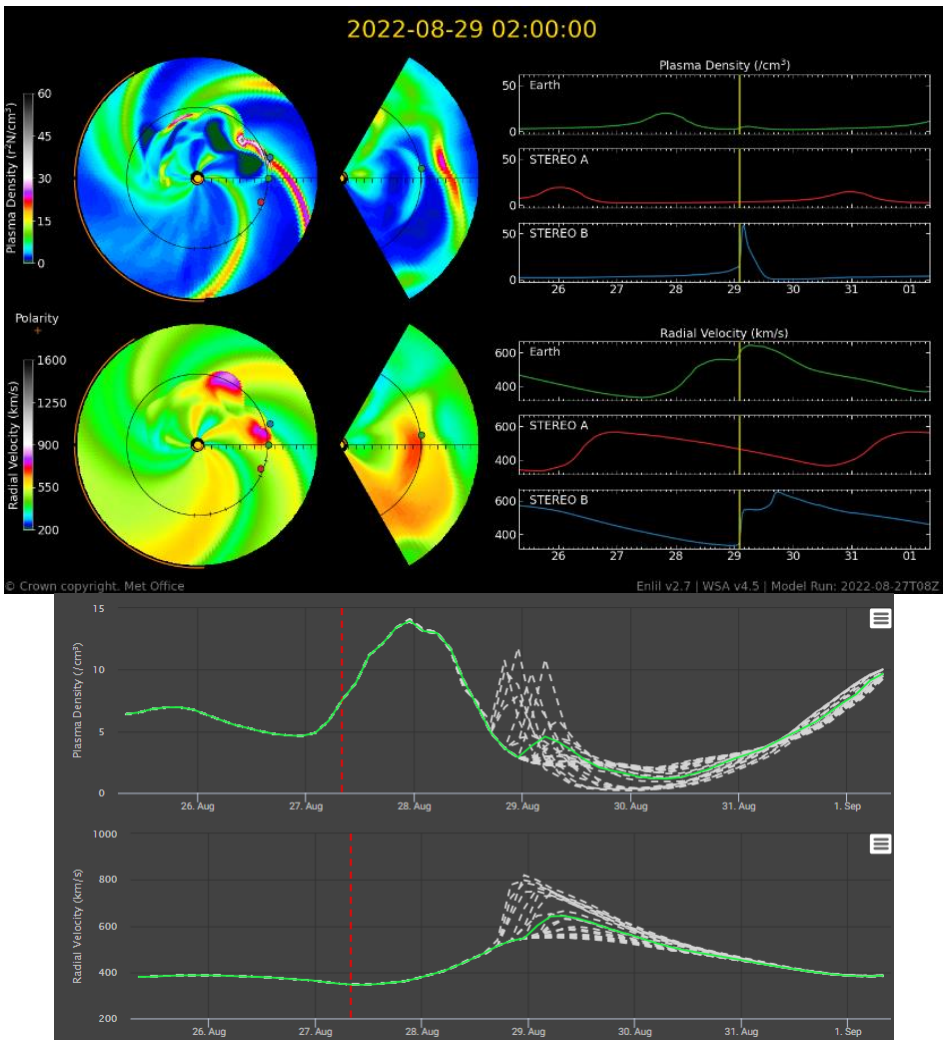


Figure 2b: ENLIL showing glancing impact



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Radio Blackouts - X-Ray Flares:

Solar Activity is currently Moderate with recent M-flares from both AR3088 Ekc/Beta-gamma in the southwest and AR3089 Eai/Beta in the southeast. Further M-flares are considered likely, with a slight chance of an isolated X-flare, with the main risk from AR3088.

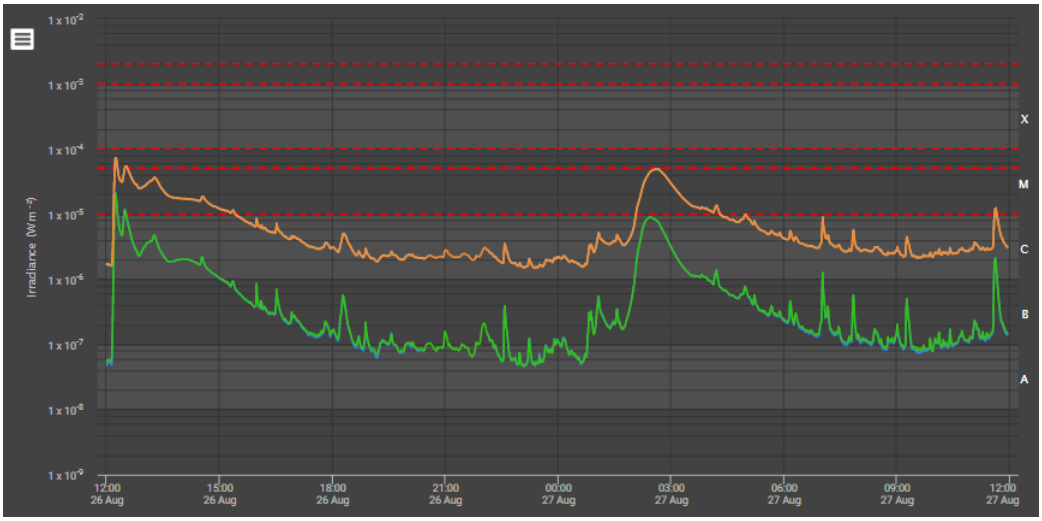
The M-flaring of AR3089, peaking M5.7 26/1215 UTC, was subsequently followed by a reduction in complexity of the region, with its spots spreading into a more standard bipolar configuration. Consequently despite the areal extent of the spot remaining similar, the risk for further significant flaring has reduced slightly.

Conversely AR3088, peaking M4.9 27/0240 UTC, has continued to exhibit growth in areal extent despite its increasing viewing angle preventing a clear analysis. Recent flaring, coupled with dynamically evolving magnetic looping observed in SDO imagery, suggests ongoing complexity that may not be apparent from line-of-sight magnetograms. This is also supported by its north-south aligned magnetic field lines, suggesting potential for increased shear across them. This gives some notable uncertainty around this region, but does suggest an increased chance for strong flares, given its size and history of flaring.

The other three regions on the disc, are generally smaller and simpler, with only a limited flare risk, however AR3086 in the south centre disc has shown some slow growth in the last 12-24 hours, and will need monitoring for any further development.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	60	30
Very Active	R3 to R5 X Class	No	25	25	20	5

Figure 3: GOES 16/17 X-ray Flux showing the sequence of M-flares.



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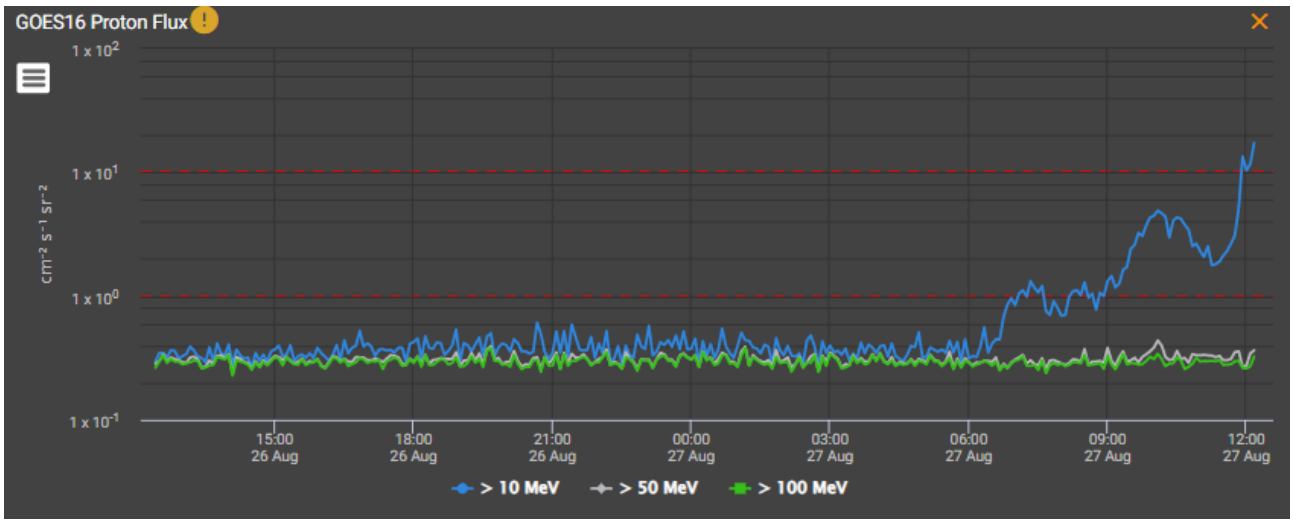
Solar Radiation Storms - (High Energy Protons):
The high energy proton flux (greater than 10 MeV) has recently been enhanced by the long period M4.9 flare of AR3088, reaching just above the S1 level. This shows the potential for any further significant flares from this region to result in the occurrence of solar radiation storms, giving a chance of further S1 or greater through days 1-3 (27th to 29th). This region is expected to rotate off the visible disc day 3 (29th), with a subsequent reduction in proton storm risk. A very slight chance is maintained however, due to other active regions currently present on the Earth-facing Sun.
Otherwise, the currently slightly above background proton flux is expected to only gradually decay back to background levels.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	100	30	20	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-16 Proton Flux rising above S1



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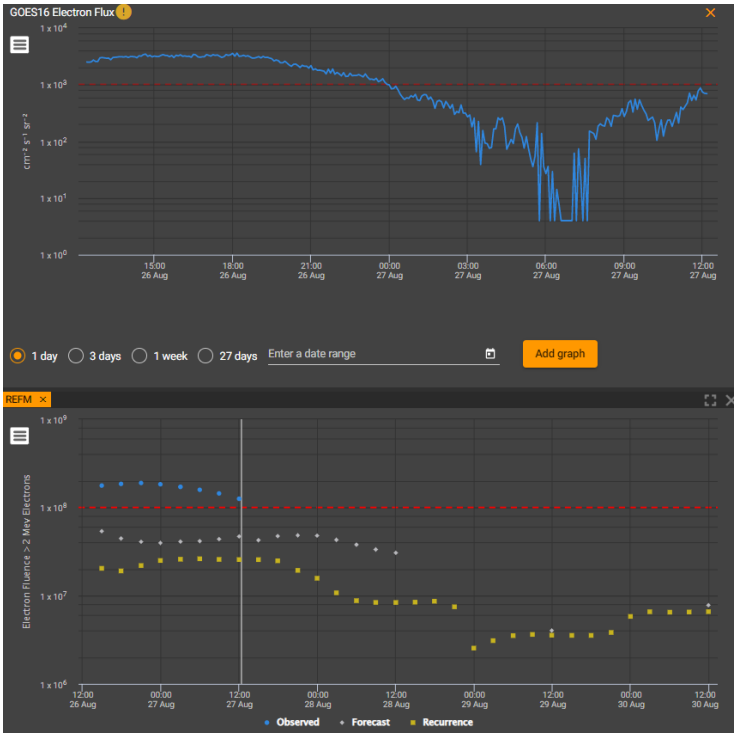
High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux, as measured by GOES16, has been High throughout the last few days, but declined to Background to Moderate levels early on the 27th. This was likely due to the combined effect of increasing density ahead of the fast wind arrival from CH18, but also potentially related to the slightly increased proton flux due to the M4.9 flare of AR3088. Recovery to high levels is currently uncertain, but likely not to occur until ongoing geomagnetic activity from recent solar wind enhancement day 1 (27th) subsides. A potential CME glance, and also further fast wind arrival on day 2 (28th) into day 3 (29th), will again limit the recovery of flux values and increases uncertainty for the latter part of the period.

The associated 24 hour fluence is currently expected to fall below Active on day 1 (27th), but with a chance of rising again through the period, albeit with low confidence. This reduction is signaled by REFM, however given the potential enhancements to the solar wind that are expected which currently won't be accounted for by this model, this is likely to be of limited reliability.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	Yes	100	30	40	50
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: GOES 166 Electron Flux and Fluence with REFM and persistence.



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